



# Knotted Versus Knotless Medial-Row Transosseous-Equivalent Double-Row Rotator Cuff Repairs Have Similar Clinical and Functional Outcomes

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**Purpose:** To retrospectively investigate the clinical and functional outcomes of patients who underwent knotted medial-row rotator cuff repair (KT-RCR) compared with patients who underwent knotless medial-row rotator cuff repair (KL-RCR). **Methods:** A retrospective chart review of patients who underwent double-row transosseous-equivalent rotator cuff repair in 2016 was performed at a single institution with 2-year follow-up. Information regarding demographic characteristics, preoperative tear size (magnetic resonance imaging), surgical variables (including method of suture stabilization), preoperative and postoperative American Shoulder and Elbow Surgeons (ASES) scores, and all complications (e.g., cuff failure, adhesive capsulitis, and persistent pain) was compiled. **Results:** A total of 189 patients met the inclusion criteria: 72 in the KL-RCR group and 117 in the KT-RCR group. No significant difference in preoperative ASES scores was found between the KL-RCR and KT-RCR groups (48.3 vs 45.4,  $P = .327$ ). Postoperative ASES scores did not differ between the groups (82.4 for KL-RCR vs 78.8 for KT-RCR,  $P = .579$ ). We found no significant difference in cuff failure rates after 2 years, determined by magnetic resonance imaging (5.6% for KL-RCR vs 6.1% for KT-RCR,  $P > .999$ ), or complication rates (11.1% for KL-RCR vs 8.6% for KT-RCR,  $P = .743$ ). **Conclusions:** The knotted approach and knotless approach to double-row rotator cuff repair showed similar outcome scores, cuff failure rates, and complication rates at minimum 2-year follow-up. **Level of Evidence:** Level III, retrospective therapeutic comparative trial.

Rotator cuff tears are a common cause of shoulder pain and discomfort.<sup>1</sup> In patients undergoing routine shoulder examinations and magnetic resonance imaging (MRI) studies, the incidence of full-thickness cuff tears has been reported to be as high as 1 in 5 patients in the general population.<sup>1</sup> Arthroscopy has

evolved into the preferred surgical technique in patients with rotator cuff tears warranting surgical intervention. Unfortunately, despite surgical and technical advancements, a large proportion of repaired rotator cuffs still fail to properly heal. A significant number of factors, both patient and surgeon driven, have been identified

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as key contributors to overall healing after repair of symptomatic rotator cuff tears.<sup>2-6</sup> In an effort to improve repair outcomes, facilitate biological tendon healing, and restore optimal anatomic biomechanics at the supraspinatus footprint, transosseous-equivalent (TOE) rotator cuff repairs (RCRs) have been used and optimized.<sup>7-12</sup> However, controversy remains regarding the best anchor configuration and suture technique.<sup>7,8,11-22</sup>

Although double-row TOE RCR has traditionally relied on knotted medial-row anchors, debate currently exists on whether to tie the medial row. Certain biomechanical studies have shown an increased contact area and less gap formation when the medial row is tied in double-row repair.<sup>16,18,22-26</sup> Conversely, Mijares et al.<sup>27</sup> showed that no significant differences exist regarding displacement across the repair site, stiffness, and ultimate load to failure. Other studies have shown that even if present, biomechanical advantages may come at the expense of heightened strain at the medial suture level where the knots are tied.<sup>16,28</sup> It has not yet been determined whether biomechanical differences (in strength and contact pressure) impact clinical outcomes, rotator cuff healing rates, or postoperative pain levels. Furthermore, it has been hypothesized that tying a knot may increase the risk of medial-row failure (type II failure) owing to potential compromise of vascular inflow to the healing tendon.<sup>25,29</sup> As a result, knotless medial anchors have been developed to improve vascular circulation and help prevent this complication.<sup>13,16</sup> However, from a clinical standpoint, the superiority of one fixation method over the other remains unclear.<sup>10-12</sup>

The purpose of this study was to retrospectively investigate the clinical and functional outcomes of patients who underwent knotted medial-row rotator cuff repair (KT-RCR) compared with patients who underwent knotless medial-row rotator cuff repair (KL-RCR). We hypothesized that the functional outcomes and clinical findings of patients, including rates of postoperative complications and rotator cuff failure, would be similar between the 2 groups.

## Methods

After institutional review board approval was obtained (No. 18D.623), patients who underwent RCR from August through December 2016 with Current Procedural Terminology code 29827 ("arthroscopy, shoulder, surgical, with rotator cuff repair") were identified. A total of 189 patients treated at a single, large multicenter institution were thus included in this study. Patients undergoing revision RCR, open RCR, labral repair, total shoulder arthroplasty, or remplissage were excluded. A minimum follow-up period of 2 years was required for inclusion.

Data from surgeons' charts and operative reports were retrospectively collected and evaluated by 3 independent

reviewers (D.N., Z.H., and R.W.P.) trained in data collection by a fellowship-trained orthopaedic shoulder surgeon (S.H.). Demographic information including age at the time of surgery, sex, body mass index, surgical laterality, and hand dominance was collected. The preoperative rotator cuff tear size was classified using MRI in accordance with the system of DeOrto and Cofield<sup>30</sup> as small (<1 cm), medium (1-3 cm), large (3-5 cm), or massive (>5 cm and/or containing  $\geq 2$  rotator cuff tendons). Preoperative and postoperative American Shoulder and Elbow Surgeons (ASES) scores were compiled.<sup>31</sup> Using surgeons' operative reports, we recorded the number of anchors used, whether a knotted or knotless TOE RCR was performed, and concomitant subscapularis repair and/or biceps surgery (either tenotomy or tenodesis). Postoperative data on repair complications (rotator cuff failure, reoperation rate, adhesive capsulitis, persistent pain, persistent wound drainage, infection, or neurologic issues) and overall rates of rotator cuff failure (as determined by radiologist MRI reports) were gathered. After surgery, patients were placed on a rehabilitative protocol wherein they were instructed to wear a sling for 6 weeks and, depending on tear size, to begin formal physical therapy at between 1 and 6 weeks postoperatively. Physical therapy began with controlled passive motion and worked to advance patients toward active range of motion. Patients underwent postoperative MRI only in instances in which clinical manifestations of repair failure were present; imaging indications in this patient subset included patients with marked pain and functional disability after the completion of their prescribed rehabilitative protocol, as well as those who experienced distinct shoulder reinjury events with physical examination findings indicative of impaired rotator cuff integrity. All surgical procedures were performed arthroscopically using medial-row anchors that were either tied and brought into lateral-row anchors or left untied and brought into lateral-row anchors to achieve double-row fixation. The number of anchors used was dependent on tear size.

## Statistics

The data were analyzed with SPSS Statistics software (IBM, Armonk, NY) to determine differences between patients undergoing knotted TOE RCR and those undergoing knotless TOE RCR. After confirmation of normality with the Shapiro-Wilk test, the Student *t* test was used to compare continuous data between groups whereas the  $\chi^2$  test was used to analyze categorical data. The Spearman rank correlation coefficient was used to assess the relations between the number of anchors used and postoperative ASES scores and between the preoperative rotator cuff tear size grade and postoperative ASES scores. A subanalysis of small or medium tears versus large or massive cuff tears was also performed to limit confounding effects. A minimal

**Table 1.** Demographic Information of Patients in KT-RCR and KL-RCR Cohorts

Characteristic	KT-RCR (n = 117)	KL-RCR (n = 72)	P Value
Age, mean ± SD, yr	59.2 ± 8.5	55.1 ± 8.6	.002 <sup>*</sup>
Female sex, % (n)	29.9 (35 of 117)	31.9 (34 of 72)	.895
BMI, mean ± SD	29.8 ± 5.3	29.2 ± 5.4	.245
Right-sided surgery, % (n)	60.7 (71 of 117)	45.8 (33 of 72)	.065
Dominant arm, n (%)			.528
Left	13 (11.7)	5 (7.14)	
Right	97 (87.4)	64 (91.4)	
Ambidextrous	1 (0.90)	1 (1.43)	
Surgery on dominant arm, %	66.70	47.70	.020 <sup>*</sup>

BMI, body mass index; KL-RCR, knotless medial-row rotator cuff repair; KT-RCR, knotted medial-row rotator cuff repair; SD, standard deviation.

\*Statistically significant ( $P < .05$ ).

clinically important difference of 11.1 was used as validated by prior research of postoperative RCR patients.<sup>32</sup> The level of statistical significance was set at  $P < .05$ .

### Results

We identified 231 patients who underwent primary RCR during the study period. Of these patients, 189 had adequate documentation and follow-up data. Ultimately, 72 patients in the KL-RCR group versus 117 patients in the KT-RCR group met the inclusion criteria and were included in the final analysis. The patients who underwent KL-RCR were significantly younger than those in the KT-RCR group (55.1 years vs 59.2 years,  $P = .002$ ). We found no significant difference between the KL-RCR and KT-RCR groups regarding sex (31.9% female patients vs 29.9% female patients,  $P = .895$ ) or side of surgery (45.8% right vs 60.7% right,  $P = .065$ ). However, significantly fewer patients in the KL-RCR group underwent repair on the dominant arm (47.7% vs 66.7%,  $P = .020$ ) (Table 1).

We observed significantly fewer small or medium tears (36.8% vs 56.4%,  $P = .013$ ) and significantly more large or massive tears (63.2% vs 43.6%,  $P = .013$ ) preoperatively in the KL-RCR group versus the KT-RCR group (Table 2). Subanalysis comparing small or medium tears versus large or massive tears showed no

significant differences in complication rates (6.9% vs 11.1%,  $P = .20$ ), revision rates (2.8% vs 3.4%,  $P = .82$ ), or postoperative ASES scores (79.88 vs 81.14,  $P = .73$ ). Furthermore, no significant difference in preoperative ASES scores was found between groups (48.3 vs 45.4,  $P = .327$ ) (Table 2).

Intraoperatively, patients in the KL-RCR group were significantly less likely to undergo concomitant subscapularis repair (6.9% vs 25.6%,  $P = .003$ ) or to undergo biceps tenotomy or tenodesis (23.6% vs 43.6%,  $P = .005$ ). In addition, we found a significant difference in the number of anchors used between the KL-RCR and KT-RCR groups (3.21 vs 2.27,  $P < .001$ ) (Table 3).

There was no significant difference between the KL-RCR and KT-RCR groups regarding the rate of collection of follow-up data (87.5% vs 78.6%,  $P = .123$ ) (Table 4). Average postoperative ASES scores did not differ between the KL-RCR and KT-RCR groups (82.4 vs 79.4,  $P = .392$ ). Most of the patients in the KL-RCR and KT-RCR groups met the minimal clinically important difference regarding preoperative-to-postoperative improvement in the ASES score (83.6% vs 85.4%,  $P = .765$ ). However, KL-RCR patients underwent follow-up for a significantly longer period on average (39.3 months vs 31.8 months,  $P = .014$ ). We observed no significant difference in cuff failure rates after 2 years (5.6% for KL-RCR vs 6.1% for KT-RCR,  $P > .999$ ), rates of all complications (cuff failure, reoperation, adhesive capsulitis, and persistent pain) (11.1% for KL-RCR vs 8.6% for KT-RCR,  $P = .743$ ), or rates of revision RCR (5.6% for KL-RCR vs 1.7% for KT-RCR,  $P = .150$ ) between the 2 groups (Table 4).

No true relation was found between the number of anchors used and postoperative ASES scores (Spearman rank correlation coefficient, 0.025). Furthermore, no relation was found between preoperative rotator cuff size grade and postoperative ASES scores (Spearman rank correlation coefficient, 0.012).

### Discussion

There were no significant differences in average ASES scores, rates of rotator cuff failure, or incidences of all other operative complications at long-term follow-up, confirming our initial study hypothesis. Therefore, both knotted and knotless TOE techniques are viable options when performing RCR.

**Table 2.** Preoperative Tear Size Breakdown and ASES Scores of Patients in KT-RCR and KL-RCR Cohorts

	KT-RCR (n = 117)	KL-RCR (n = 72)	P Value
Patients with small or medium tear size, %	56.40	36.80	.013 <sup>*</sup>
Patients with large or massive tear size, %	46.30	63.20	.013 <sup>*</sup>
Average preoperative ASES score, mean ± SD	45.3 ± 19.9	48.3 ± 18.5	.317

ASES, American Shoulder and Elbow Surgeons; KL-RCR, knotless medial-row rotator cuff repair; KT-RCR, knotted medial-row rotator cuff repair; SD, standard deviation.

\*Statistically significant ( $P < .05$ ).

**Table 3.** Intraoperative Data of Patients in KT-RCR and KL-RCR Cohorts

Operative Report Data	KT-RCR	KL-RCR	P Value
No. of anchors used, mean $\pm$ SD	2.27 $\pm$ 1.68	3.21 $\pm$ 0.9	<.001 <sup>*</sup>
Concomitant biceps intervention, %	43.60	23.60	.005 <sup>*</sup>
Concomitant subscapularis repair, %	25.60	6.90	.003 <sup>*</sup>

KL-RCR, knotless medial-row rotator cuff repair; KT-RCR, knotted medial-row rotator cuff repair; SD, standard deviation.

\*Statistically significant ( $P < .05$ ).

Although there were no differences in clinical or functional outcomes between groups, there were several differences between the 2 study populations that make these findings notable. First, there was a significant difference in the preoperative tear sizes between the 2 cohorts, with a significantly larger proportion of patients in the KL-RCR group having large or massive tears. Failure rates after large and/or massive RCR have ranged from 34% to 94% across various studies<sup>2,33-35</sup>; thus, the lack of a significant failure difference between the 2 groups may support the use of a knotless TOE RCR and the notion that its relative repair success may be underestimated in our study.

The current literature also supports the idea that acceptable functional outcomes and patient satisfaction may mask underlying failures in healing. Galatz et al.<sup>33</sup> reported the radiographic failure rate after arthroscopic repair of large and massive tears to be as high as 94% in patients who simultaneously experienced marked functional improvement and substantial pain relief in activities of daily living. This finding was further substantiated by Chung et al.<sup>3</sup>: Using a larger patient pool, they found that 39.8% of arthroscopically repaired massive rotator cuff tears showed anatomic failure despite significant functional gains. Our study substantiates this concept in that no true relation was found between preoperative rotator cuff tear size and postoperative ASES score in the knotless

versus knotted TOE RCR groups (Spearman rank correlation coefficient, 0.012). However, because routine MRI follow-up was not conducted in the absence of clinical indications of failure, the true rate of anatomic cuff failure after repair of these large or massive tears cannot be known for certain.

As previously indicated, this study found no significant difference in postoperative ASES scores when comparing the KL-RCR and KT-RCR groups. This finding corroborates the results of prior studies on this topic while including data collection from a large patient population, with the collection of follow-up data on 155 patients. In a prospective cohort investigation, Kim et al.<sup>15</sup> reported similar functional outcomes between knotless and knotted TOE RCRs of medium to large full-thickness rotator cuff tears at short-term follow-up; their study showed no significant differences in healing rates or retear rates on advanced imaging. These comparable retear rates between approaches were substantiated in a systematic review performed by Kunze et al.<sup>36</sup> in 2020, wherein the incidence and location of both type I (failure at the tendon-bone interface) and type II retears after knotless and knotted RCR were determined to be similar. The results of our study support those of Millett et al.,<sup>20</sup> Hug et al.,<sup>8</sup> and Boyer et al.,<sup>7</sup> who also found no significant differences in functional outcomes between knotless tape-bridging RCR and knotted suture-bridging RCR techniques.

Intraoperatively, patients in the KL-RCR group were less likely to undergo biceps treatment (tenotomy or tenodesis) (23.6% vs 43.6%,  $P = .005$ ), as well as subscapularis repair (6.9% vs 25.6%,  $P = .003$ ), compared with the KT-RCR cohort. Despite this finding, we observed no significant differences in ASES scores postoperatively. The idea that concomitant biceps intervention does not lead to divergent results in patient-reported functional outcomes compared with isolated RCR has been readily substantiated by other studies. Keong and Tjoen<sup>37</sup> reported that biceps

**Table 4.** Postoperative Functional and Clinical Outcome Data of Patients in KT-RCR and KL-RCR Cohorts

	KT-RCR	KL-RCR	P Value
Follow-up success, % (n)	78.6 (92 of 117)	87.5 (63 of 72)	.123
Postoperative ASES score, mean $\pm$ SD	79.4 $\pm$ 23.7	82.4 $\pm$ 19.1	.392
Patients with ASES score improvement exceeding MCID, % (n)	85.4 (76 of 89)	83.6 (51 of 61)	.765
Follow-up period, mean $\pm$ SD, mo	31.8 $\pm$ 18.3	39.3 $\pm$ 18.9	.014 <sup>*</sup>
Rate of all complications, % (n)	8.6 (10) (cuff failure in 7, adhesive capsulitis and/or stiffness in 1, and persistent pain in 2)	11.1 (8) (cuff failure in 4, adhesive capsulitis and/or stiffness in 3, and persistent pain in 1)	.743
Rate of rotator cuff failure, % (n)	6.1 (7)	5.6 (4)	>.999
Rate of rotator cuff revision, % (n)	1.7 (2)	5.6 (4)	.150

ASES, American Shoulder and Elbow Surgeons; KL-RCR, knotless medial-row rotator cuff repair; KT-RCR, knotted medial-row rotator cuff repair; MCID, minimal clinically important difference; SD, standard deviation.

\*Statistically significant ( $P < .05$ ).



tenotomy during RCR did not lead to significant postoperative differences in functional outcomes when compared with RCR performed in isolation. Similarly, Kukkonen et al.<sup>38</sup> found that treatment of the long head of the biceps tendon in the setting of arthroscopic RCR did not impair clinical outcomes as compared with no procedure.

The average number of anchors used was significantly higher in the KL-RCR group (3.21 vs 2.27,  $P < .001$ ). This finding is not surprising given that Lee et al.<sup>5</sup> showed that the number of anchors used is highly correlated with initial tear size and the KL-RCR group consisted of more patients with large or massive tears. Furthermore, our study found no true relation between the number of anchors used and postoperative ASES scores. This finding is in accordance with the results of other studies that have shown that the number of suture anchors is not an independent factor predictive of rotator cuff retear incidence or postoperative ASES scores.<sup>5,20</sup>

### Limitations

Our study is not without limitations. The patients in this study did not undergo routine follow-up imaging during the postoperative period in the absence of clinical indications; thus, the true retear rate cannot be known. Additionally, neither the preoperative degree of muscular atrophy nor fatty degeneration was recorded or controlled for in this retrospective review, which may have confounded outcomes. There was a significant difference in follow-up duration between the 2 groups, although it is not likely that this dramatically impacted outcomes considering that each group was followed up for at least 2 years. Additionally, age at the time of surgery significantly differed between the 2 cohorts, with patients in the KL-RCR group being 4 years younger (55.1 years vs 59.2 years,  $P = .002$ ). However, with the average age of both cohorts being below 60 years, this difference may not have substantially affected outcomes.<sup>6</sup>

Furthermore, this was a retrospective study, lacking randomization, thereby increasing the chance of underlying bias. Specifically, patient selection for knotted versus knotless TOE double-row repair was based on individual surgeon decision making, thus increasing the potential for selection bias in our study. Different surgeons generally contributed to each subset (5 KL-RCR surgeons vs 10 KT-RCR surgeons), which may have contributed to outcomes. Although our numbers represent a large study population in comparison to the current literature, there is potential that our numbers are too low to detect a clinically significant difference between groups.

### Conclusions

The knotted approach and knotless approach to double-row RCR showed similar outcome scores, cuff

failure rates, and complication rates at minimum 2-year follow-up.

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